

The collaboration between Int J Life Cycle Assess and J LCA Jpn

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1 Preamble

The Institute of Life Cycle Assessment, Japan (ILCAJ) was established in October 2004. The goal of ILCAJ is to promote academic activities related to life-cycle thinking and to share expert knowledge with colleagues from wider ranging backgrounds. Professor Ryoichi Yamamoto, University of Tokyo, has taken responsibility as Chairman of ILCAJ.

In April 2005, ILCAJ has successfully established its publication organ (in Japanese), The Journal of Life Cycle Assessment, Japan (J LCA Jpn). The issues appear every 3 months. J LCA Jpn publishes peer-reviewed research articles, commentaries and discussions, (technical) reports, lecture notes, and presentations of research groups in Japan, along with others. In Int J Life Cycle Assess 12(6):348–350, we were happy to announce the collaboration with J LCA Jpn for the purpose of exchanging knowledge, new insights, experiences, and information across the different languages.

The Corner: JLCA Jpn aims to be a bridge between the LCA community of Japan and that of the whole world. All

abstracts of research articles published in J LCA Jpn, as well as commentaries and discussions, will simultaneously appear in Int J Life Cycle Assess, Corner: JLCA Jpn, in order to introduce Japanese activities to our readers. In addition, some selected research papers from J LCA Jpn will be submitted to Int J Life Cycle Assess for publication following peer review. We hope that this collaboration will stimulate the global exchange of information through professional pathways. The following abstracts were published in J LCA Jpn Vol. 5, No. 1.

Professor Hiroshi Mizutani, Nihon University has become the Editor-in-Chief of our journal since January 2009.

2 Abstracts of research articles published in “The Journal of Life Cycle Assessment, Japan” (J LCA Jpn), Vol. 5, No. 1, 2009

2.1 Life cycle assessment approach on impacts of road improvement projects considering effects of traffic flow: case study for removal of a railway crossing

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Objective Road traffic contributes significantly to carbon dioxide (CO₂) emissions. Road improvement projects are one of the effective measures to reduce CO₂ emissions. In this study, a methodology based on the Life Cycle Assessment (LCA) approach is developed for evaluating environmental impacts of road improvement projects.

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Results and discussion A framework for evaluating environmental loads from road transport system including road infrastructure and vehicle traveling is proposed. The framework also enables us to analyze changes in driving conditions that are influenced by road improvement. Further, it evaluates the impacts due to induced traffic and change in traffic speed. The method is applied to a road improvement projects involving removal of a railway crossing by constructing an elevated track. A project undertaken in this study can reduce System Life Cycle CO₂ (SyLC-CO₂) because it improves driving conditions by reducing stops and congestion due to railroad crossing. However, sensitivity analysis shows the following important findings: (1) SyLC-CO₂ increases if traffic volume increases by more than 1.28 times after the project; (2) For a crossing where the traffic volume is less than 3,000 vehicles, such a project is unsuitable because the SyLC-CO₂ increases after the project; (3) Large traffic volume is not required to reduce SyLC-CO₂ if the crossing is closed long times.

Conclusions The results of a sensitivity analysis carried out under different traffic conditions indicate that there is an overall decrease in CO₂ emissions because, despite improvements in driving conditions, the environmental load contributed by road traffic is greater than the total load contributed by infrastructure construction and induced traffic.

2.2 Methodology for identifying an inter-regional passenger transport system generating less carbon dioxide

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Objective The focus of carbon dioxide (CO₂) emissions reduction policies for the inter-regional passenger transport system depends on two factors: (1) the aviation sector is the slowest to eliminate use of carbon fuels; and (2) aviation is expected to contribute more to greenhouse gas emissions than other transport modes. Therefore, the purpose of this study is to explore the possible changes in each indicator of Life Cycle CO₂ (LC-CO₂) per passenger-km and eco-efficiency considering travel speed as a result of a shift from aviation to the high speed railway system (Shinkansen). CO₂ emissions both for aviation and Shinkansen were estimated by applying the Life Cycle Assessment (LCA) method and taking into account same important parameters such as passenger demand.

Results and discussion CO₂ exhausted from aviation and Shinkansen during normal operation and the additional LC-CO₂ from new infrastructure provision were compared. The

first analyzed the sensitivity with regard to the number of passengers for a 500 km long corridor. The results indicate the following: (1) CO₂ per passenger-km generated from aviation hardly vary with the number of passengers; (2) LC-CO₂ per passenger-km for Shinkansen is inversely proportional to the number of passengers; (3) LC-CO₂ per passenger-km for Shinkansen is lower than that for aviation for the passenger volume of approximately 1,200 or more passengers per day; and (4) for eco-efficiency, the break-even point is more than around 2,000 passengers per day. The second considers the distance and travel demand for both aviation and Shinkansen. A possible shift from the current demand for aviation to Shinkansen was compared for each inter-prefectural Origin–Destination (OD) pair. Shinkansen was found to be superior for OD pairs with higher demand and shorter distances.

Conclusions This paper proposed a methodology for identifying an inter-regional transport system with lower CO₂ emissions. An application to the inter-prefectural ODs for existing airlines in Japan shows the conditions that provide an advantage of lower CO₂ emissions for aviation or Shinkansen.

2.3 Application of LCA to difference of environmental load from distribution and sales patterns: case study of soft drink in containers

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Objective The aim of this study is to evaluate the environmental load of the distribution stage which is as important as the production stage. This study constructs an LCA (Life Cycle Assessment) framework for production, which evaluates the environmental load influenced by different distribution and sales form. This framework includes the delivery, cargo work, safekeeping, sale and the shopping trip of the consumer as part of distribution stage. Vending machine, large-scale retail store and convenience store are compared as forms of sales. Details of the lifecycle environmental load of the distribution stage are analyzed, and effective measures to reduce the environmental load (CO₂) are examined.

Results and discussion This study analyzes the lifecycle environmental load of cooling a soft drink in a can and the difference among the distribution and sales forms. Percentage in the LC-CO₂ is 47% with large-scale retail store, 56% with convenience store, 57% with vending machine. It is

found that the distribution stage has a great influence on LC-CO₂. Vending machine exhausts most LC-CO₂, mainly because of refrigeration, and for large-scale retail store, shopping trip make a large share. The analyzes suggests four major measures for reducing LC-CO₂: (1) It is effective to shorten the stock time of the vending machine; (2) LC-CO₂ in buying a drink from a vending machine and consuming it immediately is less than LC-CO₂ in buying it from a large-scale retail store and putting it in a refrigerator for a long time; (3) A trade-off between the stock time in refrigerators and frequent delivery of small quantities indicates the optimal delivery interval of 6 days; (4) CO₂ emissions can be reduced by 15% if consumer make shopping trip by bus, scooter or bicycle.

Conclusions The share of distribution and sales stages is dominant. To propose the LC-CO₂ reduction measure requires an evaluation of the difference among the forms of distribution.

2.4 An application of LCA methodology for assessment and decision-making in the design of municipal solid waste management systems

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Background, aim, and scope Municipal Solid Waste (MSW) management systems play an important role in reducing final disposal of MSW. Recently, prevention of global warming in MSW transportation and treatment processes is also coming into importance. Decision makers in local regions should design the MSW management system that solves above issues and is desirable for the respective region in considering cost constraints. There are only a few studies taking into account regional MSW discharge and waste treatment properties and their perspective. In this study, we proposed a methodology to design environmentally and economically desirable MSW management systems in local regions by applying Life Cycle Assessment (LCA) and cost analysis.

Methods The central region of Iwate Prefecture was chosen as a case study. Firstly, we surveyed material and energy inputs/outputs in MSW transportation and treatment processes in the case study area. Then, Life Cycle Inventory (LCI) data of each process was calculated. Secondary, scenarios involving several MSW management systems considering patterns of MSW treatment technologies and/or MSW segregation were designed.

Results and discussion As a scenario analysis, Greenhouse Gas (GHG) emissions, SO_x/NO_x emissions, final disposal and the cost was calculated when each scenario would be

for the period from FY2005 to FY2030. From the results, we found that the MSW treatment system in which municipalities form communal MSW treatment mostly has an advantage than the municipality-based MSW treatment system in which municipalities treat MSW by themselves. We also found the trade-off relationship in the results; a system giving priority to gasification and melting facilities decreases the amount of final disposal and cost and increases GHG emissions, while another system giving priority to stoker type grate facility decreases GHG emissions and cost and increases the amount of final disposal. However this trade-off relationship is solved by enhancing waste segregation and/or bio-methanation of kitchen garbage. Additionally, we calculated the indicator value of environmental impact by the Distance-to-target method, and we evaluated a relationship between the indicator value and the cost. As the result, scenario involving the region-based MSW treatment system with bio-methanation is selected as a desirable MSW management system if reduction of final disposal is prioritize as the MSW treatment policy.

Conclusions In the actual fields, it is required not only quantitative evaluation environmental impact and cost but also qualitative investigation such as site selection of waste treatment facilities considering NIMBY phenomenon. Nonetheless, the methodology proposed in this paper is effective for local municipalities' decision support.

2.5 An approach of investigating local livestock manure treatment system by LCA: calculation of greenhouse gas emissions reduction performance utilizing a centralized biogas plan

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Objectives From the viewpoint of importance to construct local livestock manure treatment and utilization system with low environmental impact, there was required planning local manure treatment system by quantitative and comprehensive evaluation on environmental aspects and cost. We evaluated local dairy cow manure treatment and utilization system introducing centralized biogas plant using life cycle assessment (LCA) and cost analysis with optimization software and database construction on geographic information system (GIS) to confirm availability of LCA approach for local manure treatment system planning.

Results and discussion LCA approach was applied to case study, dairy cow manure treatment and utilization system at Yamada town in Chiba. As the results, it revealed that urine purification process at current manure treatment system was large impact at GHG emission. From the results of comparing GHG emission and total cost at each scenario, the alternative manure treatment and utilization system, utilizing manure compost depot for individual farm and introducing centralized biogas plant at west area was effective to reduce GHG emission. This approach was able to show the different types of equipments selection at system planning by objectives of scenario conditions. And it indicated introducing location for centralized biogas plant utilization, considered with nitrogen demands at local agricultural land. Furthermore, it calculated life cycle GHG emission by applying LCA including analyzing relation and link of several processes.

Conclusions We showed that the LCA approach, using GIS and optimization software, is able to consider local livestock manure treatment and utilization system planning for low environmental impacts.

2.6 Proposal of a construction method for a unique coefficient matrix in matrix-based life cycle inventory analysis

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Background, aim, and scope Matrix-based life cycle inventory analysis is effective to evaluate environmental impacts of systems including closed-loops (e.g. recycling). However, the matrix method has not yet been widely used because it is complicated and difficult for most LCA practitioners to adequately make a regular coefficient matrix from input/output data of processes. Therefore, this study aims to develop a general method to make a unique, regular coefficient matrix for supporting the use of the matrix method.

Methods First, five types of basic components are newly defined to express a product system. The combination of these five components allows for describing an arbitrary product system. Second, a system that is re-described using the five components can be dealt with as a geometrical figure that is expressed using the abstract concepts of nodes and edges in the graph theory. Finally, a regular coefficient matrix is made by analyzing geometrical relationships between nodes and edges.

Results It was proved that a unique, regular coefficient matrix can be obtained if the geometrical figure corresponding to a product system is a planar graph. An algorithm to make such a coefficient matrix was formulated using Euler's polyhedron theory, based on balance equations of flows of goods (e.g.

energy, materials) in a system studied. The validity of the proposed algorithm was demonstrated by applying the algorithm to a simple, numerical example: a product system including closed recycling.

Discussion and conclusions An advantage of the developed method is that the complicated flows of goods in a product system studied can be reduced to an abstract geometrical figure according to mathematically simple rules. This means that computers can easily generate a unique, regular coefficient matrix automatically from input/output data of processes in a product system. We plan to create software based on the proposed algorithm, which enables LCA practitioners to easily perform the matrix-based LCA without making a coefficient matrix on their own.

2.7 Environmental load and cost evaluation for an intermediate waste treatment and recycle system

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Objective To increase reduction in amounts of final disposal of waste and to improve the recycling rate, environmental loads and costs are weighed in this study, giving attention to the presence or absence of separate collection of plastic containers and packages for collection and gasification melting methods, and to stoker+ash melting method as an intermediate treatment.

Results and discussion Results show that the gasification melting method and stoker+ash melting method should be selected appropriately depending on the facility's incineration capacity. Furthermore, influences of the presence or absence of separate collection of other plastics on environmental loads and costs should not be great.

Conclusions Using the stoker+ash melting method, power consumption is less, as is the trend of environmental loading, than those of the gasification melting method. Although no great cost difference is apparent up to annual incineration amounts of about 60 kt, gasification melting method gives lower costs for amounts exceeding that level.

2.8 CO₂ emissions associated with foods throughout distribution channels from points of production to a consumer

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Objective Although several studies have been conducted to evaluate CO₂ emissions associated with the distribution of food, such studies have generally focused on emissions that occurred as a result of transportation from points of production to consumers. Few studies have evaluated the CO₂ emissions from food that occur during transportation between facilities and storage at various facilities and stores. Therefore, this study is conducted to evaluate the CO₂ emissions of foods using LCI analysis at each point throughout the distribution channels from points of production to individual consumers. These points also include distribution centers, facilities in which food is preserved, cut, packaged and sorted, retail stores, and delivery to a consumer's home. Estimation of the CO₂ emissions of foods throughout their distribution channels enables identification of the stage at which the most CO₂ is emitted during food distribution. In addition, the analysis conducted here can be used to compare CO₂ emissions at distribution channels with other stages of the life cycle of the foods evaluated.

Methods All analyses conducted in this study were based on an LCI analysis. The data evaluated in this study include the transported distance and power consumption associated with food at each point throughout the distribution channels. All data used in this study were provided by the Consumer's Cooperative of Tokyo (CO-OP Tokyo). The CO₂ emissions associated with food sold at a store and food that is delivered directly to consumers' homes were then estimated based on cases where individuals who walk to stores or have their food delivered to homes in Kokubunji. Fresh tomatoes and fresh pork were selected for this study because they were the vegetables and meats with the greatest consumption in 2007 based on consumer-spending according to the Family Income and Expenditure Survey in Japan.

Results and discussion The results of this study were as follows: 1. CO₂ emissions for foods that are transported by air are very high. 2. The amount of CO₂ emissions associated with tomatoes that are delivered to the consumer's home is 150 g-CO₂/kg, whereas 242 g-CO₂/kg are associated with store-bought tomatoes. This difference occurred because 137 g-CO₂/kg are emitted during refrigerating for storage and display at the retail store. These findings indicate that home delivery of food is more environmentally friendly than purchasing food at the store. 3. In the case of greenhouse tomatoes produced in Kumamoto Prefecture and sold at the store in Kokubunji, a total of 1,254 g-CO₂/kg are emitted from production to sale at the store, and 14% of these emissions occur at the store. In the case of fresh pork produced in Kagoshima Prefecture and sold at the store in Kokubunji, a total of 6,545 g-CO₂/kg are emitted from production to sale at the store, and 8% of these emissions occur at the store.

Conclusions CO₂ emissions differ significantly according to the various means of transportation, and sales. It is essential that retail stores sell their products only after determining ways of reducing CO₂ emissions and selecting products that are produced and distributed using processes that reduce the amount of CO₂ emitted. Furthermore, the use of labels detailing the CO₂ emissions associated with foods should be considered.

2.9 An estimation method of rebound effect based on entropy principle

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Objective Recently, “sustainable production and consumption” has been advocated. It is an approach from not only the perspective of “sustainable production”, which has already been employed, but also from the perspective of consumption with a view to achieving sustainability. The “rebound effect” is discussed from the perspective of “sustainable consumption”. In general, rebound effect means secondary environmental load derived from efficiency improvement. Several types of rebound effect have been reported. For instance, when a new goods or service generate surplus time and cost, they might be spent on the other action that brings about large environmental load. According to Greening (2000), such type of rebound effect is called “indirect rebound effect”. In this paper, we propose a new method of estimating the indirect rebound effect that utilizes a consumer behavior model and embodied intensity data of behavior. This mathematical model is based on the entropy principle from the field of information theory. The model calculates the everyday life pattern of a target group on the basis of statistical data on behavior when an event brings about the rebound effect under time and budget constraints. The environmental load resulting from change in behavior can be estimated.

Results and discussion The subject of our case study is teleworking and the rebound effect for the time generated by telecommuting was presumed. The case study reflects the fact that the change in life behavior pattern attributable to telecommuting leads to a reduction in CO₂ emissions as a result of the estimation even if the rebound effect attributable to telework is taken into account. There is an advantage in that the behavior of the target group can be represented on the basis of statistical data, although the proposed model has a limitation in that only the rebound effect under constraints of time and cost is considered.

Conclusions This paper proposed a new method of estimating the rebound effect and its usefulness was shown

by the results of the case study of telework. By using this method, the rebound effect caused by life behavior pattern change of the target group can be estimated without questionnaire or utility function. We intend to extend this method so as to evaluate various situations in the future.

2.10 Inventory analysis of CO₂ emission for log production of Japanese larch

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Objective Wood is generally considered to be an eco-friendly material because it is renewable and carbon-neutral. Wood is said to require less energy to produce than aluminum, steel and concrete. However, the environmental loads of wood have not been assessed on a life-cycle basis. In studying CO₂ emissions of wood and wood products, it is necessary to use life-cycle assessment (LCA). In this study, we estimated the CO₂ emissions based on life cycle inventory analysis for log production of Japanese larch from ground clearance to final cutting, using models of forest management for planted forest in Hokkaido.

Results and discussion The CO₂ emissions from log production were estimated to range from 6.1 kg/m³ to 15.2 kg/m³. In terms of the classes of site, the emissions were the greatest for second-class, followed by the first-class and the special-class. In terms of control of stands density, the emissions were lower for low-density than for medium-density. In using machinery to clear the ground, the emissions were the greatest for excavators with brush cutter attachments, followed by excavators with grapple rake attachments, bulldozers, and shoulder bush cutter. No significant differences in emissions were observed between the planting densities of 2,000 trees/ha and 2,500 trees/ha. Emissions from silviculture were found to differ greatly according to the machinery used to clear the ground; there were estimated to account for 3% to 29% of overall emissions.

Conclusions From the point of view of reducing the CO₂ related to log production, it is better to afforest areas that are higher class, and to control the stands at low densities. Also, it is not recommended to use heavy machinery such as bulldozers and excavators to clear the ground. The CO₂

emissions associated with log production were estimated to account for 0.8% to 2.0% of CO₂ fixed in the log.

2.11 Average lifespan of mobile phones and in-use and hibernating stocks in Japan

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Objective We have gradually shifted toward the sound-material cycle society, and achieved some positive results. There are many discussions on so-called E-waste cycles. The home appliance recycling law was established and enforced for relatively large size home appliances. However, there is no legislative scheme for the small size home appliance recycling, and the hibernating stock of these appliances has attracted much attention recently. In this paper, consumer behaviors on their mobile phones, such as average lifespan and the management of their EoL (End of Life) mobile phones, are analyzed with the questionnaire survey. Then, the results were utilized for the estimation of both in-Use and hibernating stocks of mobile phones in Japan.

Results and discussion We found out that the average lifespan has remained unchanged, while there is a report that the average duration of use has increased. In addition, the number of people who handed their EoL phones for recycling has obviously decreased for this decade. In the end, the amount of the stocks of mobile phones hibernating in the consumer's house is estimated as 167 million units at the end of 2007.

Conclusions These 167 million units of hibernating mobile phones make up 45% of the aggregated amount of EoL mobile phones in Japan and we need to take measures to this hibernating stock.